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Experimental Airplane Spraying for

Spruce Budworm Control

By

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and

Dosage-Mortality Relationships of Finely Atomized

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By

P. A. Godwin

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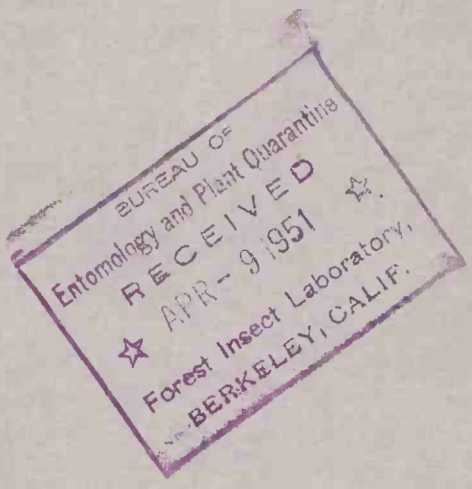
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Experimental Airplane Spraying for Spruce Budworm Control in Northern Maine - 1950 Season

W. E. Waters[1], J. W. Marsh[2], R. C. Heller[3]

Past experiments in controlling the spruce budworm by airplane spraying have demonstrated that uniform coverage by the spray is the critical factor in obtaining consistently effective control. The deposit on the foliage may be extremely variable, with some loss of material occurring between the aircraft and the forest canopy. It is important, therefore, to know what formulations - and in what amounts - will provide effective uniform coverage, i.e. insure deposit of the minimum lethal dose over all trees and all parts of the foliage attacked by the budworm. It is basic to determine this minimum lethal dose for the field conditions to be generally met.

During June a comprehensive experiment to determine certain control effects of DDT sprays, applied by airplane to control the spruce budworm, was conducted by the Division of Forest Insect Investigations, U.S.D.A., in cooperation with the Maine Forest Service and private timberland owners in northern Maine. The experiment was designed to provide information on the effect of solution as compared to emulsion sprays, droplet size, and amount of deposit on the degree of control obtained. A series of sixteen 10-acre plots in typical balsam fir stands in the Westmanland-New Sweden area was sprayed between June 14 and June 18. DDT was applied in solution and emulsion form at the rates of one-half pound and one pound per gallon of liquid per acre. Each formulation was distributed with both

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[1] Division of Forest Insect Investigations, New Haven, Conn.

[2] Maine Forest Service, Augusta, Maine

[3] Division of Forest Insect Investigations, Beltsville, Md.

coarse (290 micron mass median droplet diameter) and fine (150 micron m.m.d) atomization. The treatments were applied as shown below:

	Solution		Emulsion	
	1-1	1/2-1	1-1	1/2-1
Coarse atomization	3 plots	1 plot	3 plots	1 plot
Fine atomization	3 plots	1 plot	3 plots	1 plot

Analysis of the data yielded the following major points of information:

1. No significant difference in control was shown between solution and emulsion sprays.
2. The finer spray proved more effective than the coarse spray. The average deposit effecting 95 percent reduction was .26 lb. DDT per acre with the finer spray and .59 lb. DDT per acre with the coarse spray.
3. There was a highly significant positive relationship between dosage (deposit) and mortality.

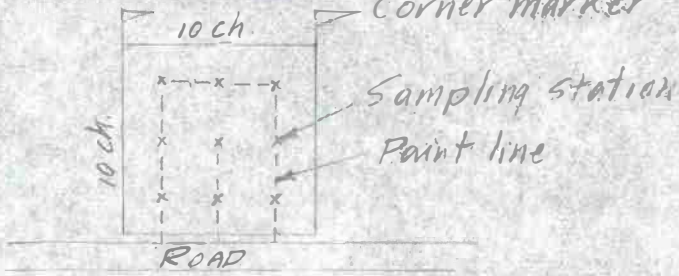
The budworm population in this area was generally light, with occasional trees or groups of trees more heavily infested. Budworm counts varied considerably between trees and between units of foliage. This is characteristic of light populations as found here. The variation was undoubtedly influenced also, by differences in stand density, stand composition, and tree size, these conditions resulting from varying degrees of cutting in the individual properties where plots were located. There was additional stratification of the budworm population due to a definite roadside or edge effect. Higher populations were found generally on trees along roads or at the edge of sizeable openings within the stands. At the time of spraying all larval instars from 3rd to late 6th were represented; the majority, however, were 4th and 5th instars.

The plots for each treatment were selected to include different stand conditions, providing different levels of budworm infestation within each treatment series. Three check plots were used also - each in a different stand type and each sampled by a different method.

The experimental conditions were made as ideal as could be feasibly done. All plots were adjacent to accessible roads, small in size (10 acres) and well marked. All flights but one were made in the early morning hours when wind and air turbulence were at a minimum. One flight was made in the evening under similarly quiet weather conditions. Temperatures at the time of spraying ranged from 50° to 65° and the wind varied from 1-2 to 6-8 miles per hour.

The airplane (piloted by R. C. Keller of the Beltsville, Md. Forest Insect laboratory) was a Stearman trainer-type biplane fitted with spray tank, centrifugal pump, boom and nozzles. The effective swath width was 132 feet (2 chains), all flights being made approximately 50 feet above the trees. In order to insure coverage of the plots additional swaths were flown on each side. The actual area sprayed for each plot was 25-30 acres. Excellent air-ground communication was maintained throughout each spraying operation by means of FM radio-telephone equipment.

Two methods of sampling were used to obtain estimates of the reduction in budworm population effected by the different treatments. Both methods utilized 9 sampling points in each plot. These points or stations were established in checkerboard fashion (see diagram below) with paint lines leading to them from the roads.



A. 15-inch Twig Sampling:-The sampling unit for this method was ten 15-inch twigs. Ten twigs were taken at each sampling station prior to and following application of the spray. The post-treatment collection was made approximately two weeks after spraying. The 90 twigs comprising each plot pre-treatment collection were returned to the field laboratory for close examination and count of budworms present. Budworm counts on the twigs in the post-treatment collection were made immediately in the field. The 15-inch twigs from each station were taken from two or more trees of different size and exposure.

Two check plots (1 and 2) were sampled by means of 15-inch twigs, check plot 1 having nine sampling stations with 10 twigs taken at each - similar to the spray plots - and check plot 3 having 100 trees, located in scattered fashion, with 1 twig being taken and examined from each tree at weekly intervals. The control results according to the 15-inch twig sampling are given in table 1.

B. Larval drop method:-The sampling unit for this method was the individual tree, a sample tree being located at each of the nine designated stations in each plot. The selected sample trees were mostly of medium size with full, symmetrical crowns. Total height of these trees ranged from 25 feet to 60 feet, averaging 35-40 feet, with an average d.b.h. of 6.9 inches.

A cloth sheet 3 feet wide was stretched the entire width of the crown beneath each sample tree, passing as close to the trunk as possible. The cloth was held six inches or more above the ground by stakes at the corners and midpoints and was weighted in the middle to prevent the larvae from wriggling or being shaken off. A narrow band of tanglefoot was placed around the top of each stake beneath the cloth to prevent

ants or other insect predators from crawling onto the tray and transporting the budworm larvae elsewhere. Sample tree data taken at this time included diameter at breast height, crown diameter (average of 2 measurements taken at right angles to each other), position in the plot, and length of cloth tray.

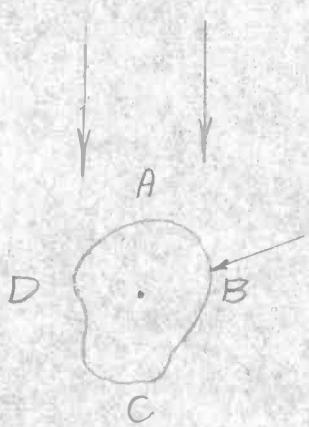
Counts of larvae dropping onto the trays were initiated several hours after spraying of a plot and were continued daily until such drop had ceased for two days or more. At that time a final check for dead larvae and survivors was made by climbing each sample tree (using complete tree-climbing equipment), cutting off all limbs and the top and dropping these onto a large sheet spread beneath the tree. Completely skinning the tree in this manner was found to be faster than cutting and lowering the tree and limbing it on the ground. Also this insured little or no loss of budworms. Every fourth branch was then examined for budworms, living or dead. The debris on the sheet was returned to the field laboratory for examination and count of budworms in it; one-fourth of these and one-fourth of the number found on the sheet during the final check were added to the branch count. All pupae were considered survivors of the spray and included a large proportion of the budworms tallied as such.

The final count , increased to the full tree basis (i.e. multiplied by 4), plus the daily check totals (computed according to the proportion of crown projection area covered by the cloth tray) gave a fairly precise estimate of the total initial budworm population, the number of killed, and the number of survivors on each sample tree. Reduction percentages were then calculated for each sample tree. The average reduction for each plot, thus estimated, is given in table 1.

Comparison was made of the estimates of control as determined by the two methods of sampling. No valid estimate could be made of the sampling error pertinent to either method, so no comparison of reliability on that basis was possible. No statistical significance could be shown for the differences in estimates of reduction for the same plots. Each method gave 8 higher and 8 lower estimates than the other method. The larval drop method comprised a much larger sample, however, so it was considered the more reliable. Observations in the field tended to verify this.

Only balsam fir trees were sampled in this experiment. The fir constitutes a major part of the stands in this area, being found in mixture with black and red spruce and northern white cedar on the low, wet sites and with mixed hardwoods and white and red spruce on higher ground.

In addition to sampling for mortality data, a record of the actual DDT deposit was obtained by erecting aluminum deposit plates on poles at half of the sample trees (i.e. 4 trees in one plot, 5 trees in the next). Two plates, each 6 inches by 12 inches, were nailed to the top of each pole, two poles being set at each of the four sides of a tree. The designated sides of all sample trees were oriented similarly, two sides corresponded to the line of flight of the airplane and two sides were at right angles to it (see diagram below).



There were, then 2 square feet of deposit plate surface at each of the four sides of a sample tree. The plates were positioned at mid-crown level, or as close to it as possible, and exposed to fall of the spray. Adjacent trees which might interfere with the spray fall were trimmed or removed. The plates were collected, marked, and packed immediately after spraying. Quantitative analysis of the DDT deposit on these plates (organic chlorine determinations) were made by the Division of Insecticide Investigations, Beltsville, Maryland.

Table 1.--Plot and Mortality Data - Airplane Spraying for Spruce Budworm Control - Maine 1950.

Treatment	Plot No.	Date Sprayed	Aver. DBH	Larval Drop Method				15-inch Twig Sample Method		
				Av. No. Survivors per tree	Av. No. Killed per tree	Aver. total Initial Population	Percent Reduction	Pre-treatment count 90 Twigs	Post-treatment count 90 Twigs	Percent Reduction
Solution	4	6/14	6.2	16.2	418.9	435.1	96.3	65	4	93.8
1-1	7	6/14	6.4	7.1	237.3	244.4	97.1	153	2	98.7
Coarse atomization	17[1]	6/18	8.6	157.3	262.7	420.0	62.5[1]	91	43	52.7[1]
Solution	13	6/14	6.5	11.7	144.5	156.2	92.5	84	0	100.0
1-1	2	6/14	6.6	14.3	218.3	232.6	93.9	113	0	100.0
Fine atomization	20	6/14	7.0	8.3	97.7	106.0	92.2	37	3	91.9
Emulsion	12	6/15	6.5	24.8	189.8	214.6	88.4	73	6	91.8
1-1	19	6/15	7.1	91.8	97.9	189.7	51.6	57	8	86.0
Coarse atomization	18	6/15	8.6	42.3	863.5	905.8	95.3	92	11	88.0
Emulsion	11	6/15	6.8	34.8	73.4	108.2	67.8	69	6	91.3
1-1	5	6/15	7.0	45.3	330.0	375.3	87.9	112	24	78.6
Fine atomization	14	6/15	6.6	12.6	274.1	286.7	95.6	92	2	97.8
Solution 1/2-1 Coarse atomization	15	6/16	7.2	28.1	180.2	208.3	86.5	54	14	74.1
Solution 1/2-1 Fine atomization	21	6/16	7.3	24.0	277.1	301.1	92.0	31	5	83.9
Emulsion 1/2-1 Coarse atomization	1	6/16	5.3	15.6	15.1	30.6	49.2	44	7	84.1
Emulsion 1/2-1 Fine atomization	16	6/16	6.4	61.8	161.8	223.6	72.4	71	27	62.0
Check Plot 1		-	-	-	-	-	-	148	74	50.0
Check Plot 2		-	7.0	487.5	12.7	500.2	2.5	219	272	424.2
Check Plot 3		-		-	-	-	-	99[2]	67[2]	32.3

1- Plot 17 was sprayed in the evening.
2- Budworm count per 100 twigs.

Statistical Analysis of Data

As the mortality data obtained by the larval drop method was considered more reliable, those values were used in this analysis. The deposit and mortality data were analyzed both separately and combined. The information obtained may be summarized briefly as follows:

A. Analysis of mortality data

1. Analysis of the mortality figures on a plot basis showed no significant differences in control between either solution and emulsion or between the fine and coarse sprays. For comparison the average reduction effected by each treatment is given below:

	Solution		Emulsion	
	Fine	Coarse	Fine	Coarse
Percent Mortality	92.65	85.60	80.93	71.13

Although the average mortality for the solution (89.13%) was higher than that for emulsion (76.03%) and the average mortality for the fine spray (86.79%) was greater than that for the coarse spray (78.37%), these differences could not be proven significant due to the variation within treatments and the relatively few values (averages) contributing to the plot analysis. These data are summarized in the analysis of variance table as follows:

Table 2.--Analysis of variance of mortality data-plot basis

Source of variation	DF	SS	MS	F	Significance
Replication	3	340.57	113.52	--	Not significant
Formulation	1	686.44	686.44	2.291	Not significant
Atomization	1	283.92	283.92	--	Not significant
AF interaction	1	7.57	7.57	--	Not significant
Total treatments	3	977.93	325.98	1.088	Not significant
Error	9	2696.53	299.61		
Total	15	4015.03			

2. Analysis of the mortality data alone was made also by means of regression using the data from the sample trees as units without regard to plot averages. The observed mortality from each of the 142 sample trees was weighted by the estimated total initial budworm population on the tree. The mortalities thus weighted were set into the general regression equation, $Y=b_0+b_1x_1+b_2x_2$, with the appropriate designations, similarly weighted, for the solution vs. emulsion and fine vs. coarse comparisons. The analysis of variance table pertinent to this data is given below:

Table 3.--Analysis of variance of mortality data--tree basis

Source of variation	DF	SS	MS	F	Significance
Solution vs emulsion	1	35.5969	35.5969	-	Not significant
Fine vs. coarse	1	103.2484	103.2484	-	Not significant
Error	139	31219.0817	224.5977		
Total	141	31357.9270			

It is obvious that the apparent differences in mortalities cannot be proved real due to the large experimental error and/or the confounding effect of one or more other factors as yet not considered.

B. Analysis of deposit data

1. The variation in deposit (DDT lbs. per acre) between plots, between trees, and between plate positions at the four sides of each sample tree where plates were erected was analyzed and the differences in all instances were shown to be significant. The analysis of variance pertinent to this data is given below:

Table 4.--Analysis of variance in deposit between and within plots

Source of variation	DF	SS	MS	F	Significance
Plots	15	16.2333	1.0824	25.489	Highly significant
Plates	3	0.4333	0.1444	3.414	Significant
Trees (within plots)	54	15.9800	0.2959	6.995	Highly significant
Interaction (plots x plates)	45	2.0412	0.0454	1.073	Not significant
Error	162	6.8595	0.0423		
Total	279	41.5403			

The significant differences in deposit between plots and between trees within plots were anticipated, the significant difference between sides of the trees was not so.

The average deposit at each side of the trees was as follows:

Side A: 0.37 lb. DDT per acre
Side B: 0.44 lb. DDT per acre-significantly higher than A and D
Side C: 0.43 lb. DDT per acre-significantly higher than A and D
Side D: 0.35 lb. DDT per acre

2. Analyzed on the basis of variation in deposit between treatments, no significant differences were shown, i.e. the differences in deposit between plots and between trees cannot be ascribed to differences between solution and emulsion or between the fine and coarse sprays. The analysis of variance for this data is given below:

Table 5.--Analysis of variance in deposit between treatments

Source of variation	DF	SS	MS	F	Significance
Replication	17	1.7058	0.1003		Not significant
Formulation	1	4.3189	4.3189	1.877	Not significant
Atomization	1	4.4694	4.4694	1.942	Not significant
AF interaction	1	3.3124	3.3124	-	Not significant
Total treatments	3	12.1007	-	-	
Error	50	114.0432	2.3009		
Total	69	128.8497			

C. Dosage-mortality analysis

The data for the 70 sample trees having deposit plates were analyzed by means of regression, the variables to be considered being expressed in the general equation

$Y = b_0 + b_1x_1 + b_2x_2 + b_3x_3$ where:

Y = percent mortality in probits
x_1= log dosage (coded by 100)
x_2= solution vs. emulsion
x_3= fine vs. coarse
b_0= estimated mortality when sum effects of x_1, x_2, and x_3 are 0, i.e. intersection of regression line with y ordinate.
b_1, b_2, b_3= coefficients of respective independent variables.

The observed values for each tree were weighted by the estimated initial number of budworms on the tree. A highly significant positive relationship was shown between dosage (deposit) and mortality, and with this effect measured by the analysis, the fine spray was shown to be significantly more effective than the coarse spray. These data are summarized in the analysis of variance table below:

Table 6. Analysis of variance of dosage and treatment of effects

Source of variation	DF	SS	MS	F	Significance
Dosage effect	1	4485.6972	4485.6972	24.1782	Highly significant
Solution vs. emulsion	1	22.2156	22.2156	-	Not significant
Fine vs. coarse	1	1052.9207	1052.9207	5.6753	Significant
Error	66	12244.7503	185.5265		
Total	69	17805.5838			

In view of the significant difference between the fine and coarse spray, dosage—mortality equations were calculated and curves drawn for each. The probit--logarithmic transformation converts the typical sigmoid curve to a straight line. These curves are presented in Graphs 1, 2, and 3, with the respective 95% confidence bands being shown in Graphs 1 and 2. This confidence band defines the area within which the true regression line will lie (odds 19 to 1). The reliability of the regression coefficients calculated for the fine and coarse sprays were tested by the t test of Fisher and were found to be highly significant. Each coefficient, however, had a relatively high standard error, reflecting much greater variation in field conditions as compared to a laboratory controlled experiment. The general dosage--mortality equation over both treatments was calculated also and drawn in Graph 4.

The average dosages effecting 50 and 95 percent mortality were calculated by each equation (these values can be taken from the graphs also).

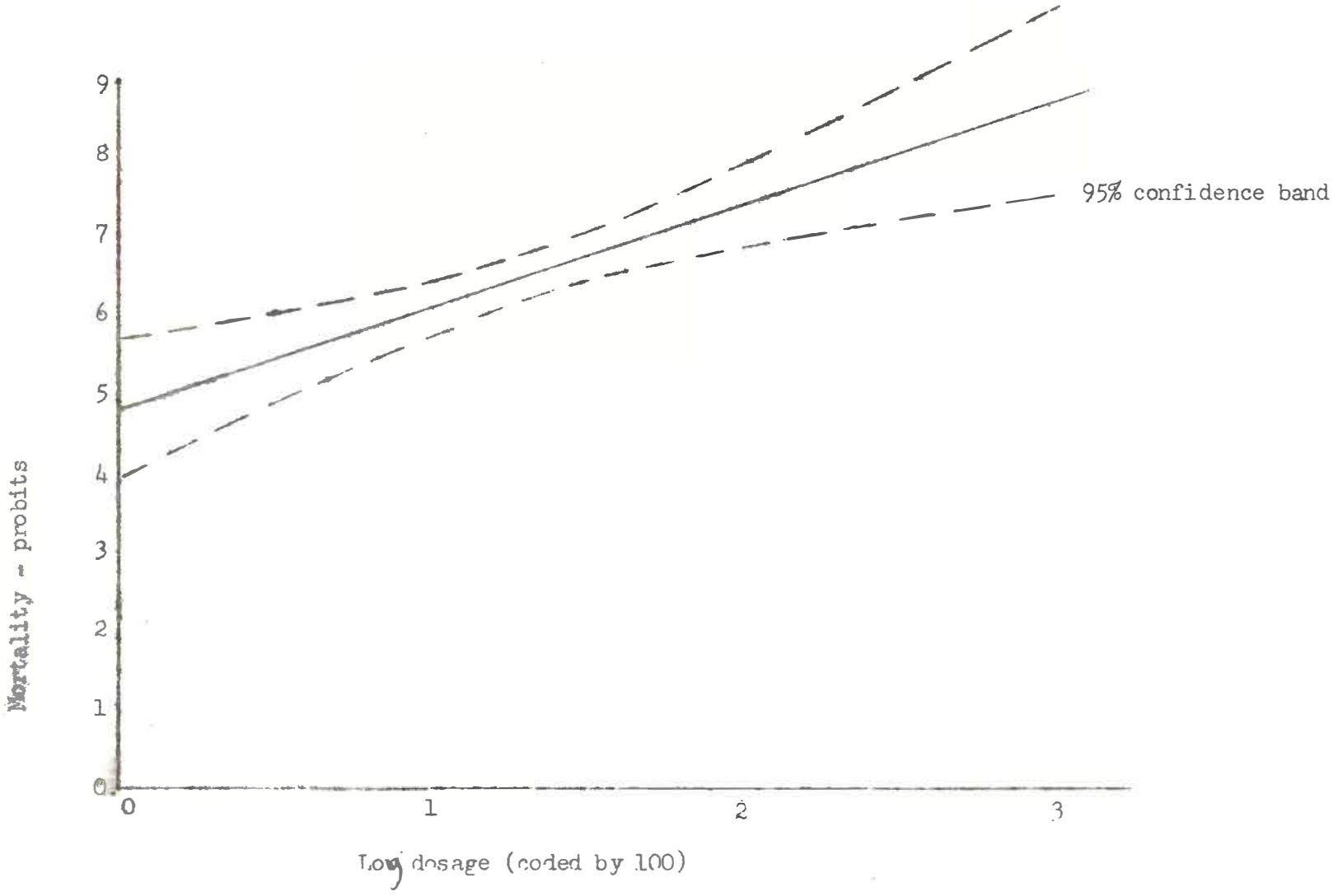
The dosage-mortality equations with their respective LD 50 and LD 95 values and estimates of the precision of the respective regression coefficients are summarized below:

Table 7.--Dosage--mortality values for fine and coarse sprays and the general regression

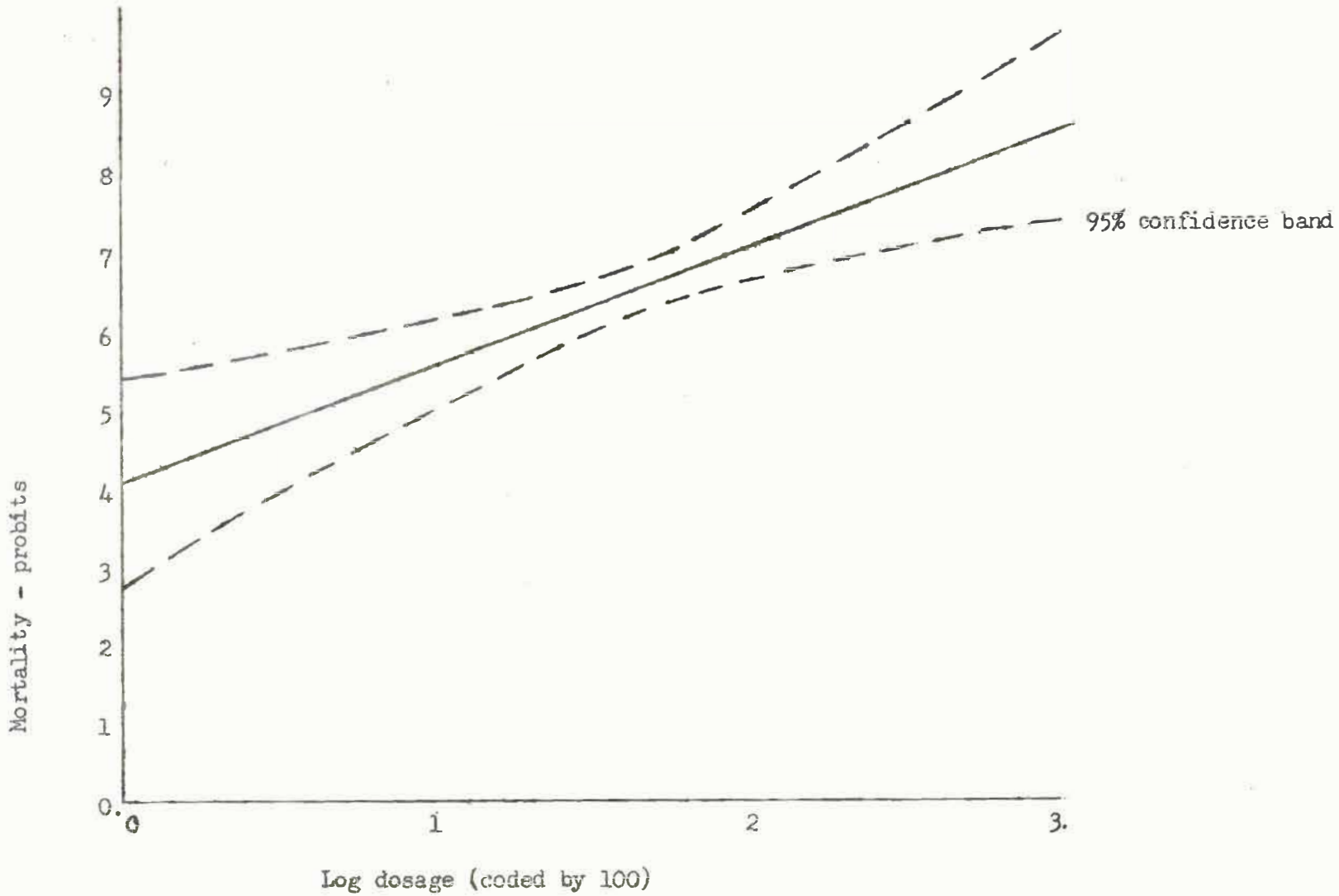
	Equation	Standard error of b	SE(b) as % of b	LD 50 lb DDT/A.	LD95 lb DDT/A
Fine atomization	Y=4.7977+1.2990x	± 0.3294	25.4	0.014	0.264
Coarse atomization	Y=4.0148+1.4855X	± 0.4000	26.9	0.046	0.589
General regression	Y=4.3243+1.4180X	± 0.2605	18.3	0.030	0.433

With regard to the design of field experiments such as this, one point was made clear. Analysis of data on a plot basis is generally inadequate. Variable conditions and too few units of information contribute to high experimental error, necessitating both recording and analysis of the data in terms of smaller individual units, such as single trees.

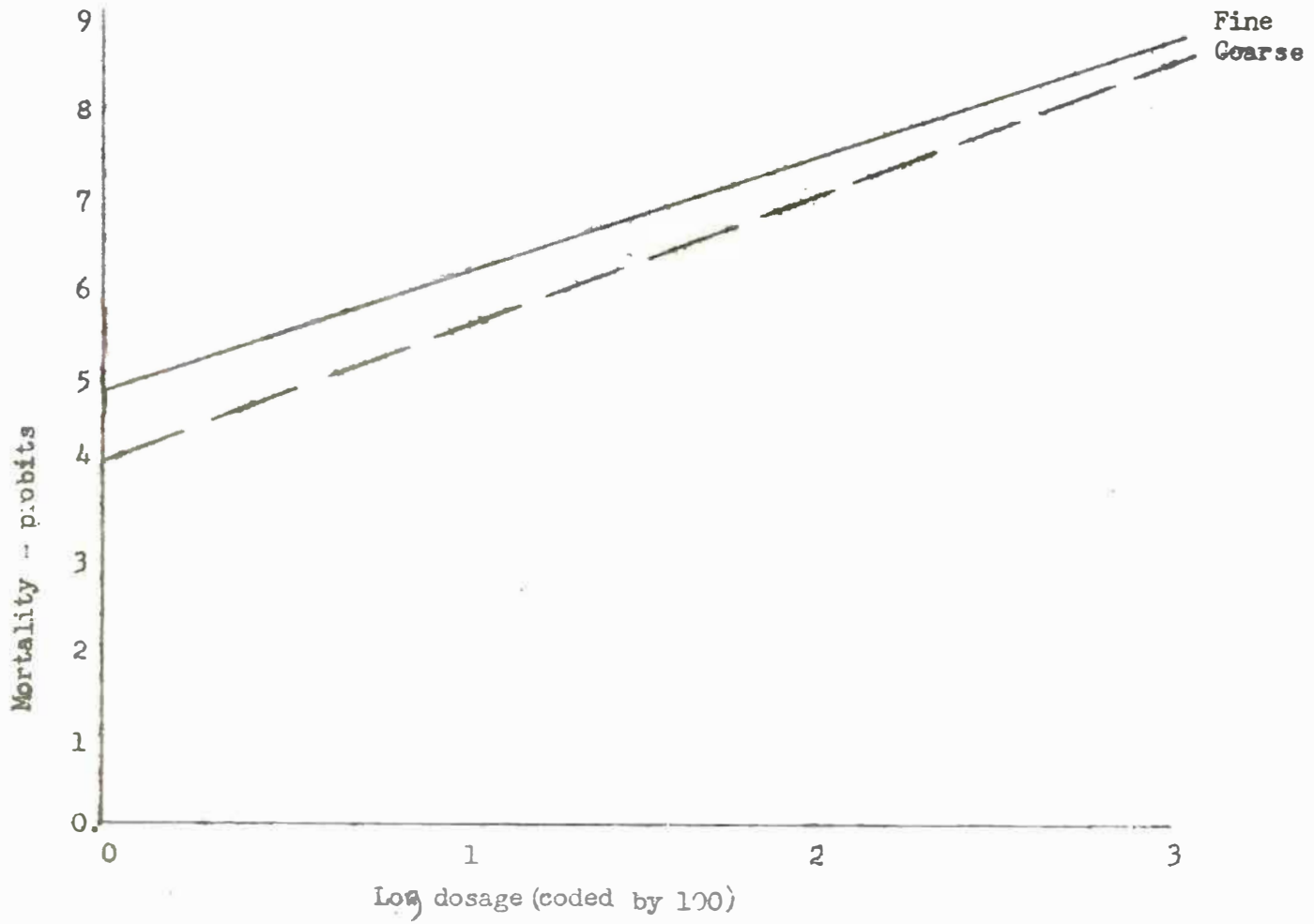
Graph 1 - Fine atomization



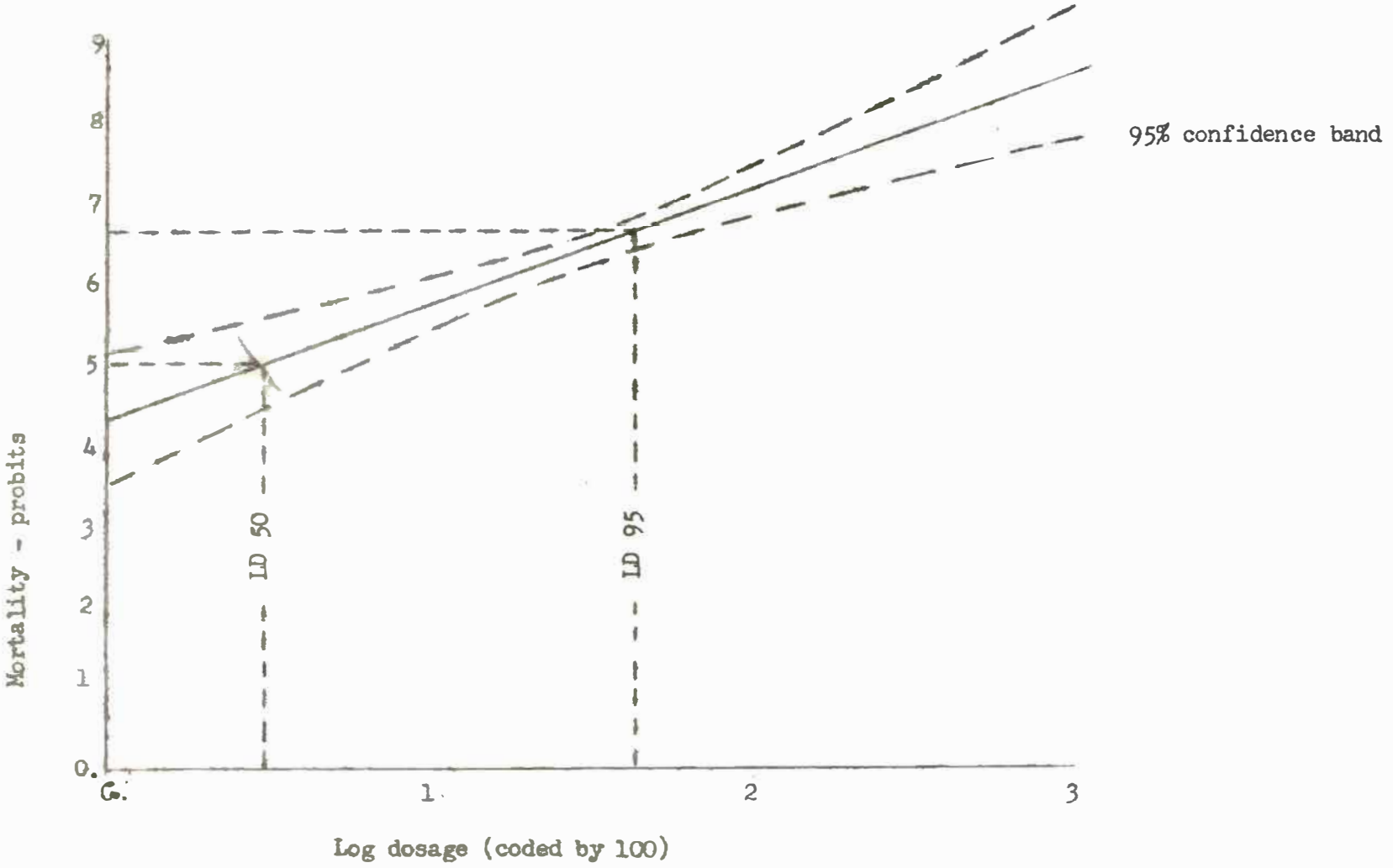
Graph 2 - Coarse atomization



Graph 3. - Dosage - mortality curves
Fine and coarse atomization



Graph 4 - Combined dosage - mortality curve



DOSAGE-MORTALITY RELATIONSHIPS OF FINELY ATOMIZED DDT SPRAYS USED AGAINST THE SPRUCE BUDWORM

P. A. Godwin

There has been a long standing need for more precise dosage-mortality data for forest insects. A number of large scale field experiments in which spray material was collected on plates, analyzed and the deposit correlated with mortality have been carried out against the gypsy moth, white-pine weevil and spruce budworm, but because of the unevenness of spray deposition under field conditions the dosage-mortality relationships have not always been reliable. With this experiment more accurate dosage-mortality data were obtained for the spruce budworm. The experiment was so designed that additional information was gained on the effect of droplet size, the comparative toxicity of emulsions and solutions and the time of application of DDT sprays as they effect spruce budworm control. While an experiment such as this can show, for example, that droplets of 80 microns are more effective in reducing budworm numbers than droplets of 150 microns; factors in the field may nullify this greater effectiveness. Thus the experiment can not answer the broader questions regarding field operations.

The general plan of the experiment was to spray fifth and then sixth instar larvae with solutions and emulsions of DDT at concentrations of .01, .10, .25, .50, and 1.00 pound per gallon and at the rate of one gallon per acre. Two droplet sizes (80 microns m.m.d. and 150 microns m.m.d.) were used.

Field collected larvae were used in the tests. Twenty larvae on a piece of balsam fir foliage, in a vial of water, were used as the test unit. The larvae were placed on the foliage about twenty four hours before they were to be sprayed so that there would be a resumption of the normal feeding habits.

For the insecticide formulations the desired amount of technical grade DDT was dissolved in one and one-half quarts of Socony Vacuum solvent PD 544 B. Number two fuel oil was added to make up a gallon of solution. Triton X-100 was used as the emulsifier in making the emulsions.

The apparatus used to dispense the spray material was developed by J. P. Secrest at Beltsville, Md. This machine will deliver, by means of an electro-mechanical timing device, a predetermined gallonage of insecticide. By adjusting the air pressure used to atomize the spray material droplets of a desired size can be produced.

Spray deposit was calculated by a colorimetric procedure. For this purpose DuPont oil red dye was included in each spray formulation. Before each test a glass plate was exposed in the spray chamber. The deposit was washed from the plate with Acetone and, after proper dilution, compared with the standard by a Spencer Direct Result Colorimeter.

To determine droplet size standard microscope slides, coated with General Electric Dry Film, were exposed in the spray chamber and the droplets measured with an eyepiece micrometer.

Four replicates were run for each test. After exposure the test larvae were placed in waxed cardboard trays and kept in an unheated shed. The temperature fluctuated considerably, rising to 70-75° F. during the day and falling as low as 60° F. at night.

Daily examinations were made of the test units and the mortality noted. The mean percent mortalities, 7 days following exposure, at each dosage level, after being corrected for natural mortality (Abbotts formula) are shown in Table 1. Natural mortality was 20 percent for the fifth instar and 7 percent for the sixth instar larvae.

Table I. The mean percent mortality, corrected for natural mortality, after seven days exposure.

Lbs. DDT per Acre	5th instar DDT emulsion at 80 microns M.M.D.	5th instar DDT emulsion at 150 microns M.M.D.	5th instar DDT solution at 80 microns M.M.D.	5th instar DDT solution at 150 microns M.M.D.	6th instar DDT emulsion at 80 microns M.M.D.	6th instar DDT emulsion at 150 microns M.M.D.	6th instar DDT solution at 80 microns M.M.D.	6th instar DDT solution at 150 microns M.M.D.
.01	8.05	4.23	12.38	0.00	2.05	0.68	0.34	3.08
.10	91.52	72.51	72.84	79.66	83.50	49.31	45.20	53.36
.25	88.13	88.11	84.72	89.83	76.65	83.56	79.45	62.95
.50	94.91	84.72	100.00	98.30	87.67	89.00	84.87	86.30
1.00	96.61	96.61	100.00	94.91	98.63	93.15	94.52	79.39

Each test unit value not the mean value of the four replicates, as in the table, was used to obtain a measure of the dosage-mortality relationships and also compare the four treatment effects. These data were analyzed by means of regression.

The general equation for this regression analysis was:

$$Y = b_0 + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4$$

where

Y = calculated percent mortality (corrected for natural mortality) in terms of probits.

x_1= log dosage (coded by 100).

x_2= formulation (solution vs. emulsion).

x_3= droplet size (80 microns m.m.d. vs. 150 microns m.m.d.)

x_4= larval instar (5th instar vs. 6th instar).

b_0= point of intersection of regression line with y ordinate, i.e. the estimated percent mortality when $x_1 \ldots x_4$ are equal to zero.

and $b_1 \ldots b_4$ = coefficient of independent variables.

This analysis yielded the following information: 1) the increase in concentration of DDT in the sprays effected an increase in budworm mortality (2) no significant difference was shown between the mortality caused by DDT solution and that caused by DDT emulsions (3) the finer droplet size effected consistently higher mortality than the coarse droplets, and (4) the mortality of larvae in the fifth instar was consistently higher than the mortality of larvae in the sixth instar. The analyses of variance pertinent to the evaluation of these data is given below.

Table II. Analysis of Variance

Source	DF	SS	MS	Variance ratio	Significance
Concentration	1	793.4110	793.4110	350.09	Significant
Formulation	1	0.2624	0.2624	0.115	Not significant
Droplet size	1	7.8808	7.8808	3.47	Significant
Larval instar	1	24.9078	24.9078	10.99	Significant
Error	35	89.8221	2.2663		
Total	39	916.2841			

In view of the differences shown, dosage-mortality equations were calculated for each of the combined treatments. These are shown in graph 1.

The values relevant to the dosage-mortality data are shown in Table III. The treatment combinations of droplet size as applied to the two instars over both emulsion and solution are tabulated in order of effectiveness.

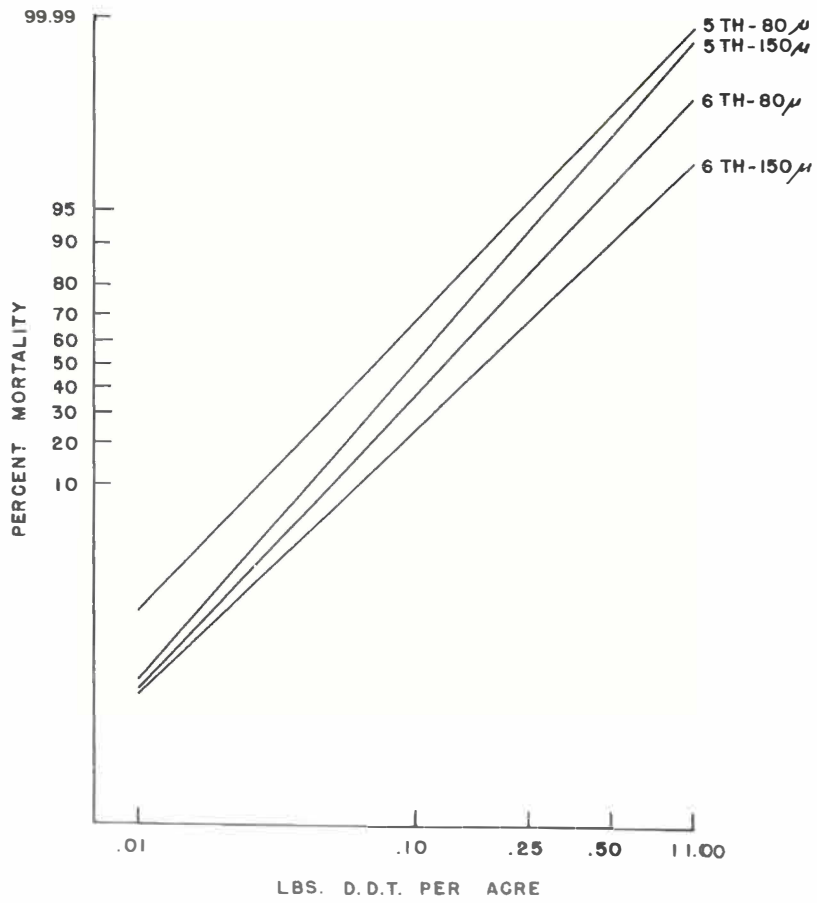
Table III. Analysis of Regression Data

Treatment	Regression Coefficient b	SE(b)	SE(b) as % b	Regression Equation	LD50 in pounds per acre	LD95 in pounds per acre
5th instar at 80u	3.1452	0.3031	9.6	Y= 2.3081 + 3.1452x	.07	.24
5th instar at 150u	3.4719	0.3238	9.3	Y= 1.4860 + 3.4719x	.10	.31
6th instar at 80u	3.2564	0.2613	8.0	Y= 1.4012 + 3.2564x	.12	.40
6th instar at 150u	2.7662	0.2375	8.5	Y= 1.5856 + 2.7662x	.17	.67
Combined	3.1599	0.1491	4.7	Y= 1.7053 + 3.1599x	.11	.36

The regression coefficients in each of the four equations were found to be highly significant.

A number of factors seem to be the source of some error. 1) Since the test larvae were field collected, the age of the individual insects varied considerably. Ecdysis occurred in a number of individuals, taking them out of the fifth instar, and reducing feeding and movement. The same is true of pupating sixth instar larvae. 2) The area in the spray chamber available for exposing the test units was small so that complete coverage was not always assured. Further, the distribution of the spray material over the test unit was uneven. 3) The solutions distributed at 150 microns caused some burning of the new balsam needles; these needles were not eaten by the larvae.

These factors of error tend to reduce mortality, consequently the estimates of LD_{50} and LD_{95} as stated herein are conservative.



Graph 1.

Dosage - mortality curves